Hybrid Chaining Inference Technique

V. Paramasivam
Indian Institute of Technology, Madras, India

D. P. Kulkarni
Satpur, Nashik, India

INTRODUCTION

Expert systems are computer programs, that try to emulate the functioning of real human experts, in a particular field. As the human expertise is expensive, perishable and not easily available to everyone who needs it, expert system development is gaining momentum.

Expert systems are also called knowledge-based systems because of the stress given on the domain specific knowledge base. This knowledge is handled in a much different fashion than in the conventional programs. Whereas in conventional programs, the knowledge is mingled with the algorithm in the program statements, in a typical expert system, domain specific knowledge and the algorithm are separate. This algorithm, which has the problem solving general knowledge, is called "inference engine". Most of the inference methods that have been developed for rule-based expert systems, can be grouped in two major catagories, as per their performance, viz., forward chaining and backward chaining inference methods.

Forward Chaining Inference Technique

In a rule based system, knowledge is codified in the form, IF-conditions, THEN-actions. It is easy to represent the thumb rules used by human experts in this simple form. When some conditions are satisfied, an expert takes a particular decision. When all the conditions in the IF portion of a rule are satisfied, an expert system makes all the actions in the THEN portion of that rule, true. In other words, that rule is "fired". Firing of a rule increases the available information and invokes other rules. This chain reaction can be started by providing some initial information in the form of basic input. If sufficient information is given, it would go on generating more and more information, firing various rules, until the final decision is reached. This is called forward chaining strategy. The final decision desired is given in the form of a goal to be pursued. The inference process goes on until either this goal is reached or no more rules could be fired indicating inadequacy of the initial information or the knowledge base or both.

Backward Chaining Inference Technique

Inference process can be started without giving any initial information. If only the final goal is given, the system tries to fire the rule whose THEN portion contains the desired goal. This rule can be fired only if the IF portion is satisfied; so the system makes these conditions "subgoals" and pursues them. This is called backward chaining strategy. These two methods have been well illustrated (Waterman, 1986).
Comparison of the Two Techniques

As the forward chaining inference runs on the available information or data, it is called a data driven method. Firing of a rule is due to some available or inferred information. Backward chaining is called a goal driven method, because it always tries to pursue the given goal and forms subgoals in order to achieve that goal. With this description, the forward chaining strategy sounds more desirable as it proceeds on the basis of available information. This is true especially at the beginning of inference process, when the input basic information leads to some fast intermediate conclusion. However, in the later stages, some of the inferred information leads to some unnecessary conclusions. The firing of rules goes on until the rule with specified goals is fired. Backward chaining gives a more efficient way of reaching the desired conclusion. Software techniques for these two methods are quite different and usually only one of them is used for an application. So, the characteristics of the knowledge domain to be handled, decide the better suited inference strategy.

Selection of Inference Technique for a Given Problem

As explained earlier, for a given application, one inference technique would be more suitable than the other.

For knowledge domains that contain a large number of parameters or "variables", and when some starting input information is typically available, forward chaining is more efficient than the backward chaining method. Problems involving "planning" decide the course of action for given conditions. As it is difficult to "guess" the right solution at the beginning, the goal driven method would not be the right choice.

Problems involving "diagnosis" have a fixed set of possible solutions. Efficient method for such a problem would be backward chaining. The inference engine will assume one of the possible solutions as the goal and try to prove it.

Unfortunately, not all the problems can be grouped in these two types. A structural design domain would have a large number of parameters, with several possible solutions. Knowledge domain for such an application would be large and illstructured. There would be some typical input parameters like structural dimensions, forces, material characteristics etc. The solution would be a combination of some decisions and thus there would be several stages of conclusions. For the starting stages, forward chaining would be more efficient, whereas in the later stages backward chaining would be better. Hybrid chaining strategy, thus becomes the best alternative for this type of problems. As it incorporates advantages of both of the major methods, it is the ideal choice.

General Features of the Technique

As previously explained, inference engine emulates the functioning of human brain. It manipulates the domain specific knowledge base, gets information about the problem at hand from the end user and infers conclusions. This general inference process is illustrated in Fig. 1.

In hybrid chaining mechanism, the general functioning would remain same but the ordinary inference engine would be replaced by a more sophisticated module. This module would contain forward chaining inference engine, backward chaining inference engine and a "controller".

Forward chaining and backward chaining are two different techniques and the efficiency of hybrid chaining is due to the use of the right technique at the right time. This choice is made by the "controller".

A client usually consults an expert with some basic information about his problem. When an end-user gives such information to this expert-system, controller employs forward chaining strategy.
The input information is stored in what can be called the local memory. Forward chaining engine matches conditions of rule with this local memory. If all the conditions are satisfied, the "actions" are added to the local memory. If all the conditions are not satisfied, that rule is abandoned and next one is considered. Even if one of the conditions is found to be false, that rule is rejected. This reduces the search space, and increases efficiency especially when for a real world application there are a large number of rules. This is similar to a human expert striking off some of the possibilities right at the beginning and deciding the thought direction. The concept of the local memory is well described (Brownston et al., 1985).

Forward chaining inference engine checks rules one by one, and the order in which rules are considered can affect the inference time. In the present study, the rules are put in three levels. The first level rules need only basic information to satisfy all their conditions. Such a rule does not depend on the firing of another rule. A rule in the third level needs only intermediate conclusions to satisfy its conditions. That is, all the conditions in such a rule appear as actions in some other rules. Level two rules have both the types of conditions. Obviously, at the beginning, level two or three rules are not likely to get fired. So at that time, the search space is restricted to level one only. Later on, when no more rules can be fired in this level, search space is kept only in the next two levels.

**Use of Backward Chaining in Hybrid Chaining Technique**

When no more rules are fired in the given search space, and the desired goal has not been reached, the controller invokes backward chaining engine.

Backward chaining is a goal driven method, that tries to fire the rule with goal value as an action. In order to satisfy this rule, its conditions are taken as subgoals and pursued in the same fashion.

A desired goal can lead to several possibilities. For example a goal parameter "structural material" can be one of steel, reinforced cement concrete or timber. Backward chaining engine takes one of the values as a hypothesis and tries to
establish it as explained earlier. When it comes across a basic level condition in the IF portion of a rule, it gets that information from the end-user by asking a question. The facts thus given by the end-user or intermediate conclusion inferred by the system may indicate that the assumed hypothesis is false. In such a case that value is abandoned and next value is considered.

Before taking up the new hypothesis, control is passed to the forward chaining mechanism. With "forward elimination" several unwanted rules are rejected. This reduces the search space and effectively helps the backward chaining process.

![Diagram of Hybrid Chaining Inference Process]

**Fig. 2: Hybrid Chaining Inference Process**

The best possible hypothesis is chosen for backward chaining, on the basis of the number of basic conditions required from the end-user. For example, if "structural material is steel" requires fewer facts from the end-user than "structural material is concrete", then the former is taken as the first hypothesis. This is similar to a human expert, who, when presented with some facts, starts thinking in the direction most likely to succeed.

This hybrid chaining inference process, in which the control is transferred between forward and backward chaining, until the desired goal is reached, is shown in Fig. 2.

**SUMMARY AND CONCLUSIONS**

Hybrid chaining is an inference technique that makes the best use of forward chaining and backward chaining strategies. Technically, it contains both the inference engines, with a controller that invokes them at appropriate stages.

Whereas forward chaining makes the best use of given information, backward chaining is useful for getting information from the end-user.

An expert system shell, that uses hybrid chaining inference technique, was developed at Indian Institute of Technology, Madras. The shell also has interactive facilities for creating a knowledge base. On this shell, a knowledge base for "Preliminary Design of Industrial Buildings", was developed. This
REFERENCES


